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BRIEFER ARTICLES

ANTHOCEROS AND ITS NOSTOC COLONIES.

The association of the liverwort Anthoceros with the blue-green alga, Nostoc, has long been known and has been studied with considerable care. The significance and value of this association have been speculated upon; but, as far as I know, no experiments on the subject have been reported. The anatomical relations of the two associates have been studied and described, but I do not know that cultures of Anthoceros from the spore on sterilized soil have been attempted. I shall here describe both the culture of Anthoceros, and, at the risk of some repetition of facts already recorded by others, the anatomical relations of the Nostoc to the surrounding tissue.

Anthoceros fusiformis Aust., and *A. Pearsoni* M. A. Howe fruit here abundantly in May. Their spores can then be collected almost or quite unmixed and free from the spores of other small plants, and may be kept air-dry for months. The dry season ordinarily lasts from mid-May to October, and during this time usually no rain falls. The spores germinate out of doors soon after the first abundant rain has thoroughy moistened the soil to a depth of several inches. The natural "resting-period" for the spores is, therefore, four or five months long, but the spores retain their vitality much longer. They may also be made to germinate in much shorter time. The "resting-period" seems to be, therefore, a matter of natural conditions rather than of transmitted habit.

The soil on which I grew plants from the spore was brought into the laboratory from the bank on which these plants, along with other small archegoniates, grow abundantly during each rainy season. After thorough air-drying, the soil was freed from pebbles, pulverized in a mortar, and put to a depth of a centimeter or slightly more in crystallizing dishes of thin white glass. These dishes were about 8^{cm} in diameter, 3.5^{cm} in depth, and were covered by the lids or bottoms of Petri dishes. These covers do not fit tightly; at the same time that they exclude dust and maintain the moisture of the air, they permit fair ventilation. The soil was invariably moistened from the beginning with boiled distilled water, for I wished to avoid any accumulations of salts in these undrained cultures from using our hard tap-water. These covered dishes were now divided into two lots of equal number, one lot being put aside in the dark for a few days and the other steam-sterilized for two or three hours on three successive days. This sterilization proved thorough so far as blue-green algae are concerned, since none developed in the dishes. A certain amount of infection is unavoidable, and a few cultures in each lot had to be thrown away because of the development of some "damping-off" fungus. But on the whole the plants in my cultures have done quite as well as those out of doors. During the growing season now ending they did better than those out of doors, because November and December were cold and dry.

Eleven or twelve weeks after sowing, the small plants already bear archegonia and antheridia when the cultures are kept under suitable conditions of illumination. Cultures kept too dark will contain few if any fruiting plants, though the plants may be normally large. From this fact, though I have not attempted to support this view by further investigation, one may infer that light acts as a stimulus to the development of the reproductive organs as VÖCHTING[1] and KLEBS[2] have shown to be the case in certain flowering plants and fresh-water algae.

On comparing the young plants on sterilized and on unsterilized soil the greater size and more robust appearance of the plants on sterilized soil is evident. The plants on sterilized soil contained no Nostoc colonies. The plants on unsterilized soil contained Nostoc colonies, few of them bore reproductive organs, and they appeared less thrifty. But the young Anthoceros plants on unsterilized soil were obliged to compete not only with each other but with several other sorts also. Without attempting an exhaustive list of these other plants I may record the presence, in the cultures, of prothalli of *Gymnogramme triangularis*, fronds of *Fimbriaria Californica*, two or three small mosses, both protonemal and adult, some green algae (especially a small Vaucheria), some blue-green algae (Nostoc, Oscillatoria, Anabaena), chickweed, and grass. Besides these, which started from spores, seeds, or other resting stages, there were small plants which had held over the dry season as CAMPBELL[3] has described, fern prothalli and plants of Fimbriaria and Anthoceros.

Where young plants of Anthoceros have to compete in small cultures with such a number of individuals and of kinds of already fairly established plants, it is natural to assume that this amount of competition may have much to do with their less thrifty appearance. However, the presence of Nostoc colonies on the soil does not necessarily imply the infection of all Anthoceros plants near them. As a matter of fact, a good many Anthoceros plants free from Nostoc can be found on unsterilized soil. These look better than those beside them containing Nostoc colonies, and as well as those in the dishes of sterilized soil.

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[1] VÖCHTING, H., Ueber den Einfluss des Lichtes auf die Gestaltung und Anlage der Blüthen. Jahrb. Wiss. Bot. 25:149. 1893.

[2] KLEBS, G., Die Bedingungen der Fortpflanzung bei einigen Algen und Pilzen. Jena, 1896.

[3] CAMPBELL, D. H., Resistance of drought by liverworts. Torreya 4:81. 1904.

Where cultures receive light mainly from the side, as is generally the case in a laboratory, Anthoceros plants, like fern-prothalli and the thalli of Fimbriaria, turn up from the surface of the soil, presenting their normally upper surface toward the window and bearing rhizoids on the shaded side. These plants necessarily contain fewer Nostoc colonies than those remaining flat on the soil, for the younger and elevated parts are less accessible to Nostoc filaments. Comparisons of older cultures than those just described shows that Anthoceros plants containing only one or two algal colonies are nearly or quite as thrifty as those with none, and are decidedly more vigorous than those with many.

PRANTL[4] attributed an advantage to Anthoceros from its association with Nostoc, on the ground that Nostoc might fix the free nitrogen of the air and contribute its products to the liverwort, but the weight of evidence seems now to be against the assumption that blue-green algae by and of themselves add at all to the combined nitrogen in the soil,[5] whatever the results of their association with N-fixing soil bacteria may be. The fact that, in my cultures at least, Anthoceros does better when free from Nostoc, removes all ground for PRANTL's claimed advantage from the association so common in nature.

On the other hand JANCZEWSKI's designation of the Nostoc colonies as parasitic[6] is not logically justified by my cultures or by the luxuriance in growth and by the fertility of these two species of Anthoceros in this region in ordinarily good seasons. Last year they throve as I never saw them before. This season has been by no means so favorable, dry weather having come long before the plants, held back by the cold and dryness of November and December, could ripen their spores in large numbers. All I feel inclined to say is that Nostoc certainly does not benefit Anthoceros, which in fact does better without it.

It is a matter of common observation that many blue-green algae thrive best where there are considerable quantities of organic matter.[7] It is conceivable that Nostoc profits from intimate association with green plants, but to prove the parasitic nature of such association is very difficult. I could not detect that the Nostoc cells, filaments, and colonies within the thallus of Anthoceros appear healthier, or larger, or grow more rapidly, than those on the moist earth near by. The cells of this and many other blue-green algae are so small and the organs of the cell so slightly differentiated that differences between cells are by no means noticeable. From the evidence at hand it is equally unsafe to say that Nostoc is or is not parasitic in Anthoceros.

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[4] PRANTL, K., Die Assimilation freien Stickstoffs und der Parasitismus von Nostoc. Hedwigia **28**:135. 1889.

[5] PFEFFER, W., Pflanzenphysiologie, 2te Auflage, **1**:386–7, 393. 1897.

[6] JANCZEWSKI, A. DE, Vergleichende Untersuchungen über die Entwickelungsgeschichte des Archegoniums. Bot. Zeit. 377 ff. 1872.

Passing now to anatomical considerations, PRANTL[8] asserts that the characteristic development of the thallus cavities and the formation of internal hairs follows the entrance of Nostoc filaments only, not of any other small plants. The manner of infection I will not go into, for it has been repeatedly described.[9] The invading filament, if it survives, gives rise to a colony, spheroidal in form and enclosed in gelatinous matter which increases with the growth of the colony. Mechanical pressure, increasing with the growth of the colony and with the amount of water absorbed, is brought to bear against the surrounding cells of the thallus, enlarging the cavity which the Nostoc filament entered through one of the slime-slits on the surface. Another effect of the increasing pressure is the compacting of the immediately surrounding tissue. But because the Nostoc colony is not homogeneous, being in part cells and in part the gelatinous product of these cells, the pressure is not equal over all parts of the surface. The gelatinous matter between the filaments is softer and more readily penetrated or displaced than the filaments themselves. If small thallus cells lie opposite to and in contact with these gelatinous parts of a colony, they will necessarily be pushed forward by their neighbors. As has long been known, chains of cells, constituting the internal hairs above mentioned, do grow into the colonies and among the filaments of Nostoc. Other organisms, though they may enter the body of the liverwort, either do not exert any pressure at all, being smaller than the cavities they occupy, or form such compact masses that there is no chance for the surrounding cells to grow out as chains.

From this consideration of the structure and mechanics of the Nostoc colony, we are led to see the fallacy of PRANTL's argument that, because cavities and hairs do not develop in the familiar way except where Nostoc colonies are, the liverwort must profit by such associates. It is simply a matter of mechanics. Where the resistance is less than growth can overcome (and this is the case between the Nostoc filaments in the gelatinous mass), the liverwort cells will grow out, forming short hairs. The growing and swelling colony as a whole will enlarge the cavity in which it lies. There are other intercellular spaces throughout the thallus, but these are not enlarged because not occupied. There is no conceivable advantage in their enlargement.—GEORGE J. PEIRCE, *Stanford University, California.*

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[7] See for example KIRCHNER, O., Schizophyceae in Engler & Prantl's Natürliche Pflanzenfamilien. I. 1^a:48. 1898.

[8] PRANTL, K., *loc. cit.*

[9] CAMPBELL, D. H., Mosses and Ferns, Ed. 2, 128. New York, 1905.

DISTRIBUTION AND HABITS OF SOME COMMON OAKS.

SINCE writing the paper under this title, which appeared in the June number of this journal, I have been in Milwaukee and had the opportunity of examining the oaks in two herbaria, probably representative of any that may be found there. In the Public Museum were two specimens labeled *Quercus palustris* Du Roi. One had an acorn, and as far as determinable by this and the leaf-characters, was *Q. ellipsoidalis;* it is certainly *not* what it is labeled. The other was without fruit, and was doubtless the same species. In the herbarium of Dr. LEWIS SHERMAN, one of the older residents of Milwaukee and an acquaintance of Dr. LAPHAM, was a specimen labeled as above. It had an acorn cup but no nuts. This showed at least that it was *not Q. palustris.* All the evidence tends to the conclusion that the real pin oak does not occur in the region from which these specimens were taken.—E. J. HILL, *Chicago.*